

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 6,880,386 B1  
DATED : April 19, 2005  
INVENTOR(S) : Hans-Ulrich Krottil et al.

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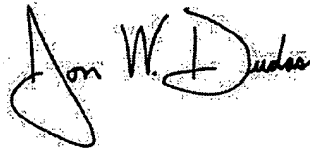
It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page should be deleted and substitute therefor the attached title page.

Replace sheets 1 through 12, showing Figs. 1 through 13D, with attached sheets 1 through 12 showing Figs. 1 through 13D.

Signed and Sealed this

Thirteenth Day of September, 2005

A handwritten signature in black ink, appearing to read "Jon W. Dudas". The signature is stylized with a large, looped initial "J" and a cursive "Dudas".

JON W. DUDAS  
*Director of the United States Patent and Trademark Office*

(12) **United States Patent**  
Krottil et al.

(10) Patent No.: **US 6,880,386 B1**  
(45) Date of Patent: **Apr. 19, 2005**

(54) **METHOD AND DEVICE FOR  
SIMULTANEOUSLY DETERMINING THE  
ADHESION, FRICTION, AND OTHER  
MATERIAL PROPERTIES OF A SAMPLE  
SURFACE**

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(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/869,789**

(22) PCT Filed: **Jan. 4, 2000**

(86) PCT No.: **PCT/DE00/00003**

§ 371 (c)(1),  
(2), (4) Date: **Jul. 23, 2002**

(87) PCT Pub. No.: **WO00/40946**

PCT Pub. Date: **Jul. 13, 2000**

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G01N 19/04; G01B 11/30; G01B 21/30**

(52) U.S. Cl. .... **73/105**

(58) Field of Search ..... **73/105, 9, 866,  
73/801; 250/306-307**

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

5,444,244 A 8/1995 Kirk et al.  
5,477,732 A 12/1995 Yasue et al. .... 73/105  
5,503,010 A 4/1996 Yamanaka

(Continued)

**FOREIGN PATENT DOCUMENTS**

DE	44 37 081	4/1995	.....	G01N19/04
DE	9421715 U1 *	7/1996	.....	H02N2/04
DE	19502822 A1 *	8/1996	.....	H01J37/28
DE	197000747 A1 *	7/1998	.....	H01J37/28
DE	197 28 357	1/1999	.....	H01J37/28
EP	0 611 945	11/1997	.....	G01B1/34
EP	0 896 201 A1	2/1999	.....	
WO	WO 00/40946	7/2000	.....	

**OTHER PUBLICATIONS**

Kazushi Yamanaka et al "Lateral Force Modulation Atomic  
Force Microscope for Selective Imaging of Friction  
Forcess" *Japanese J. Apple Phys.* vol. 34, Part I, No. 5B, pp  
2879-2882, May 1995.\*

(Continued)

Primary Examiner—Thomas P. Noland

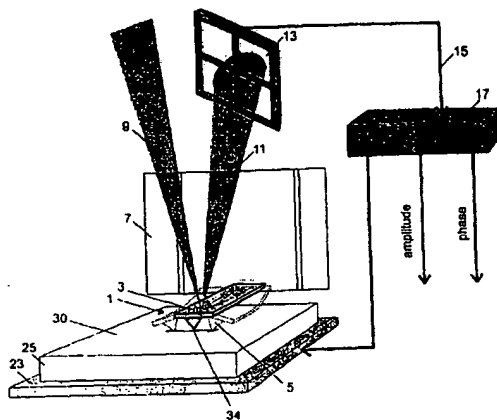
(74) Attorney, Agent, or Firm—Baker & Daniels

(57)

**ABSTRACT**

A process for the location-resolved simultaneous detection  
of the adhesion and friction as well as possibly of other  
material properties of a sample surface to be examined by  
means of a raster probe microscope comprising a raster  
probe. The raster probe and/or the sample with sample  
surface are moved until at a point of the sample surface to  
be examined the raster probe interacts in a determined  
manner with this surface. The raster probe and/or the sample  
are subjected to a vertical oscillation, and a first measuring  
signal characterized by the deformation of the raster probe  
is recorded. A second measuring signal characterizing the  
deformation of the raster probe is recorded, wherein the  
raster probe and/or the sample are subjected to a horizontal  
and/or vertical oscillation. From these two measuring sig-  
nals the desired material properties are determined. For the  
detection of the entire surface area to be examined the raster  
probe and or the sample are again moved and for the  
repetition of the measuring process described brought into  
contact with the sample surface in the above described  
manner.

10 Claims. 12 Drawing Sheets

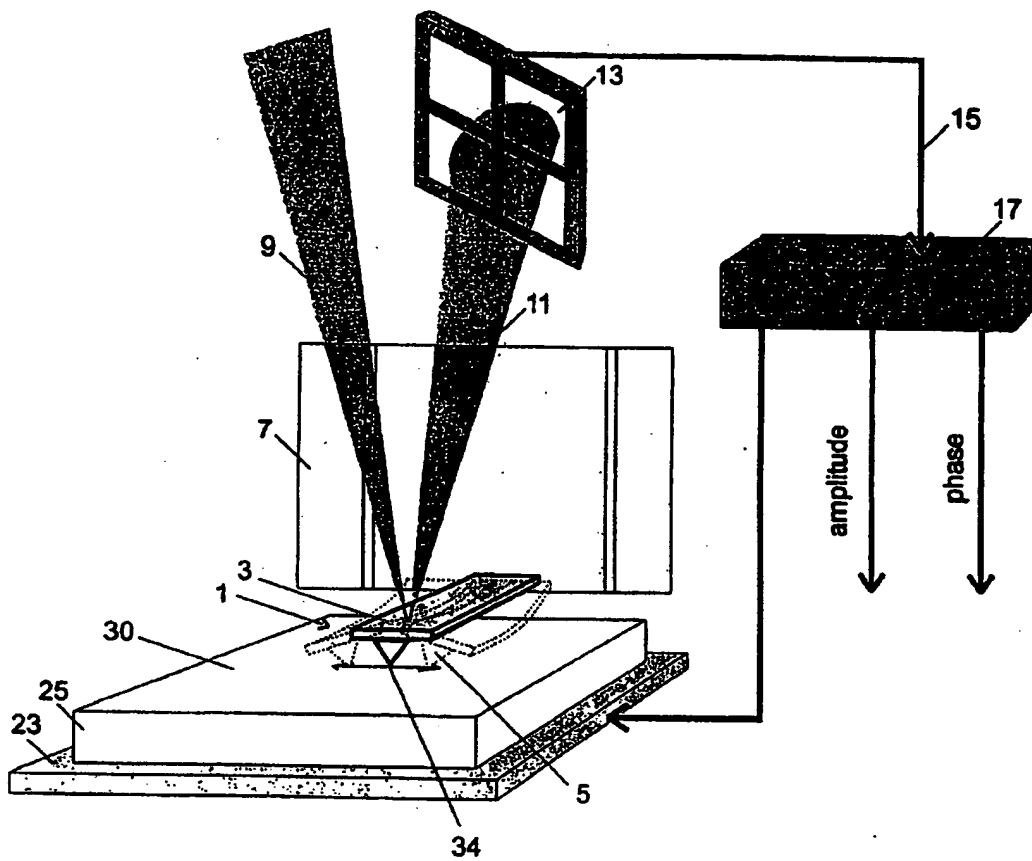


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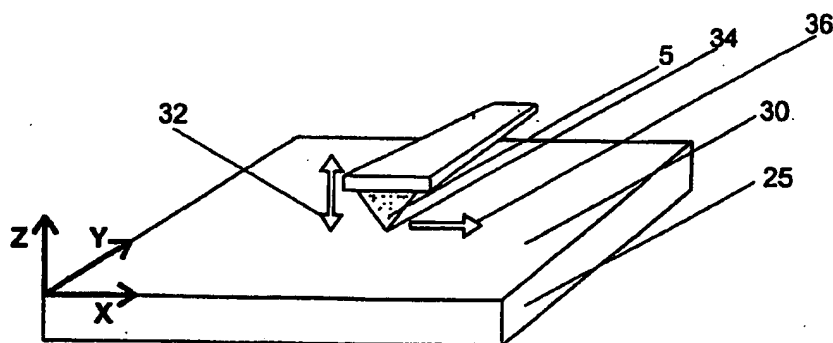


Fig. 2

NORMAL  
PERPENDICULAR FORCE

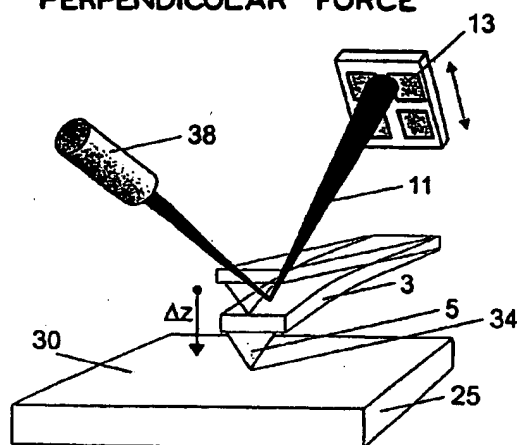


Fig. 3A

LATERAL FORCE

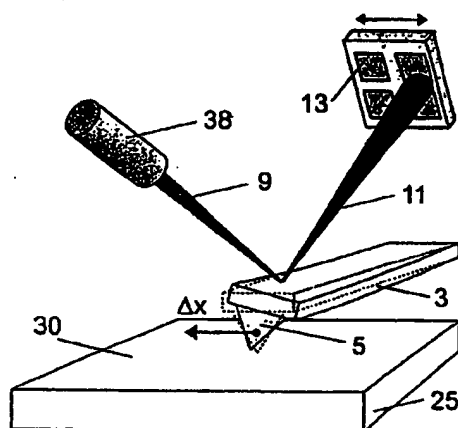
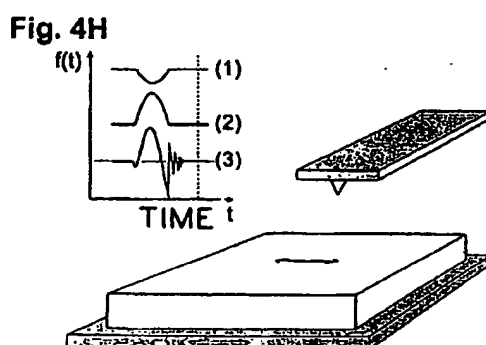
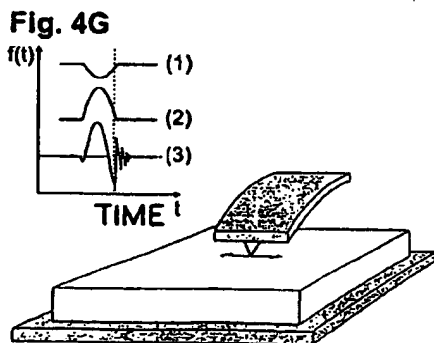
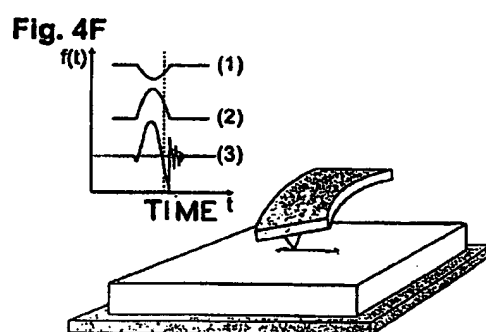
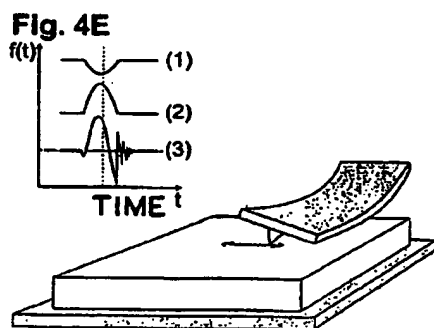
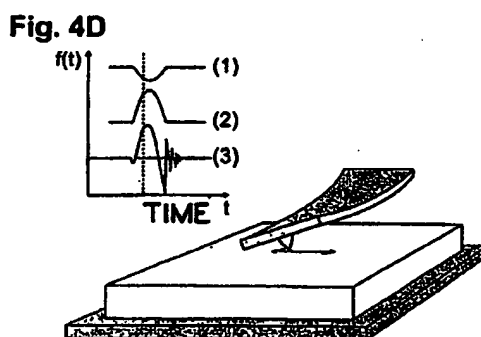
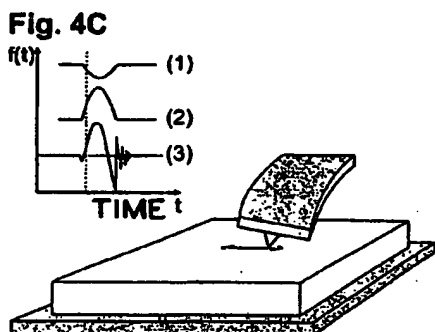
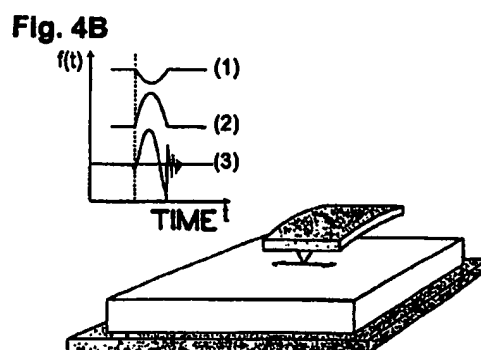
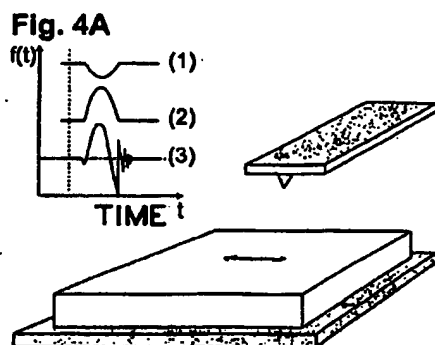


Fig. 3B



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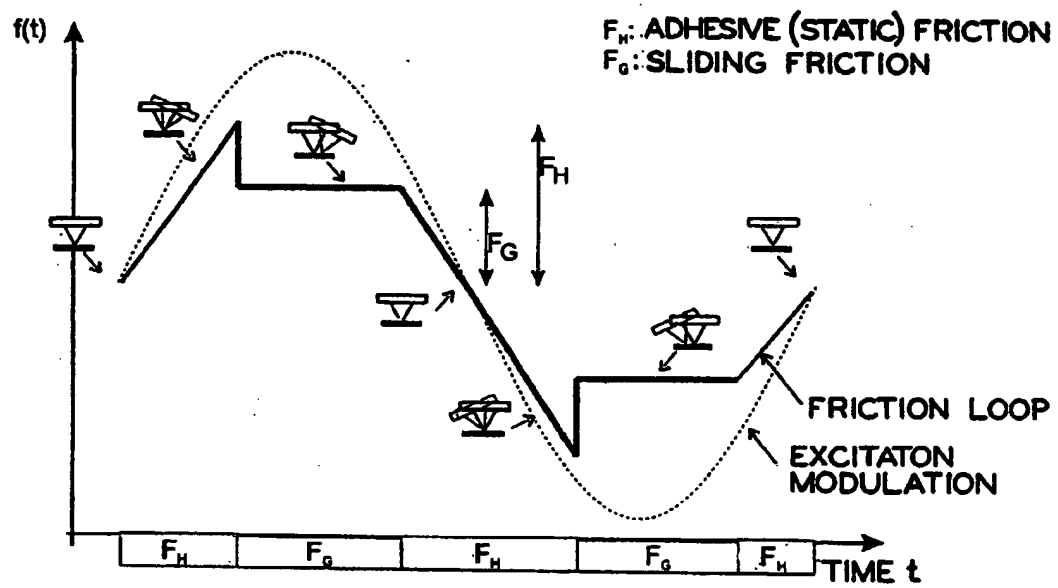


Fig. 5

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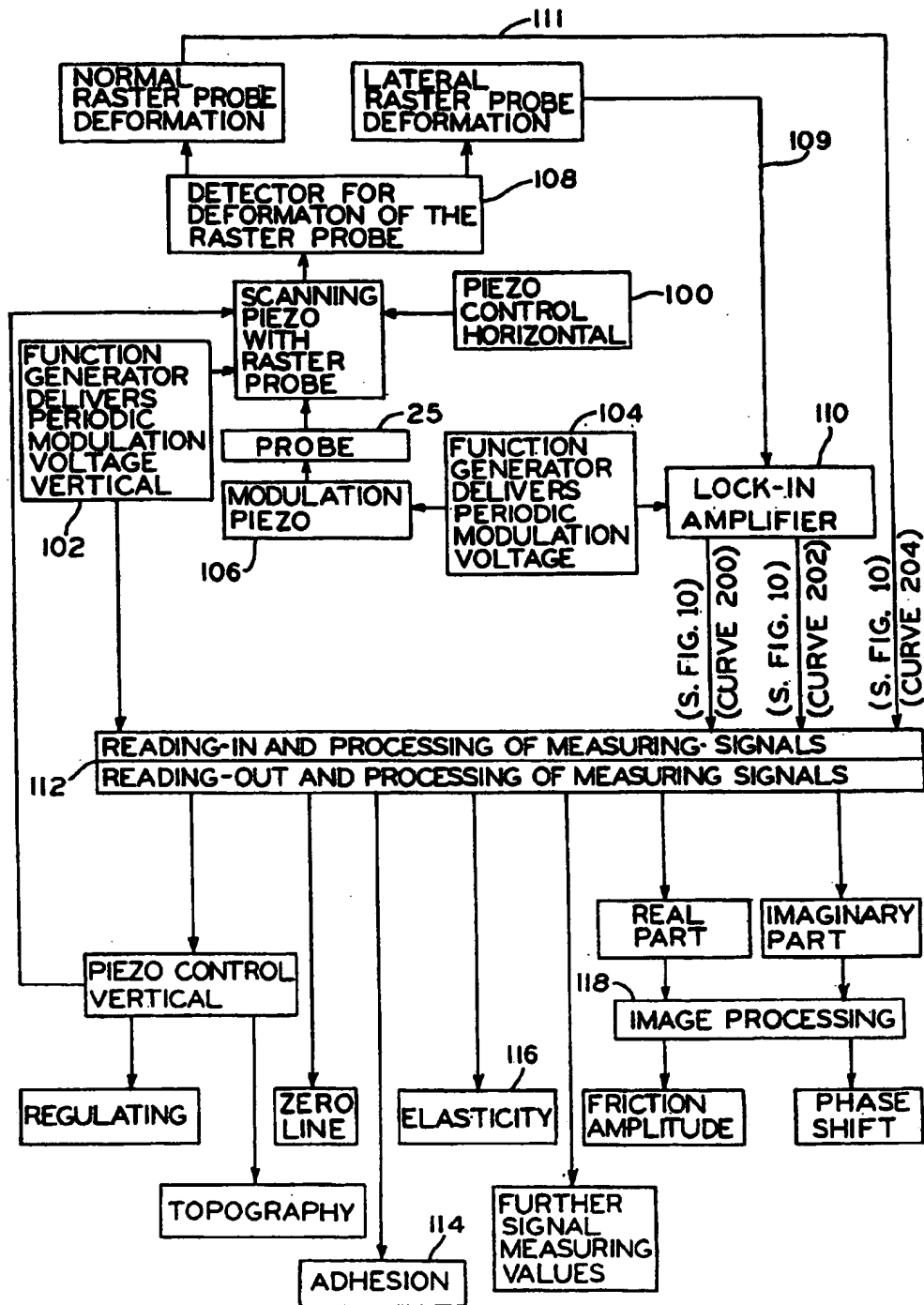


Fig. 7A

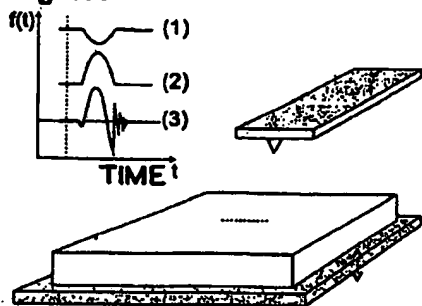


Fig. 7B

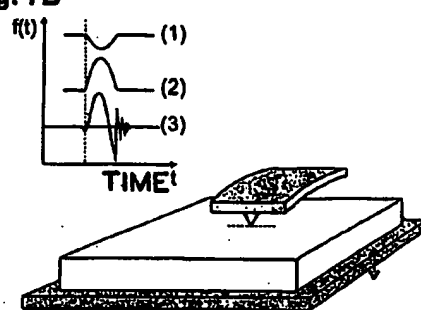


Fig. 7C

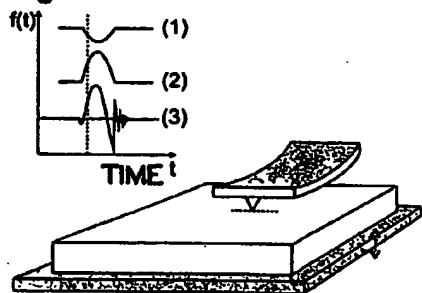


Fig. 7D

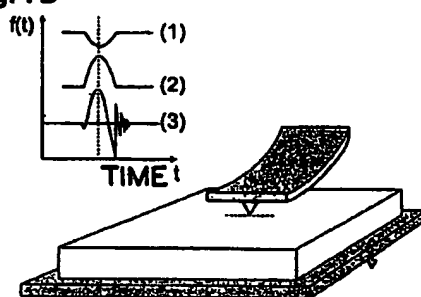


Fig. 7E

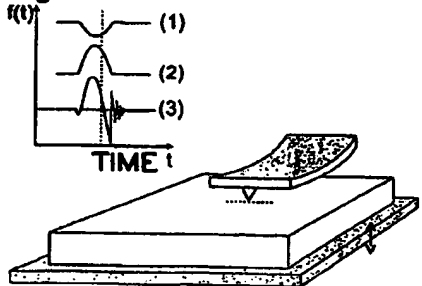


Fig. 7F

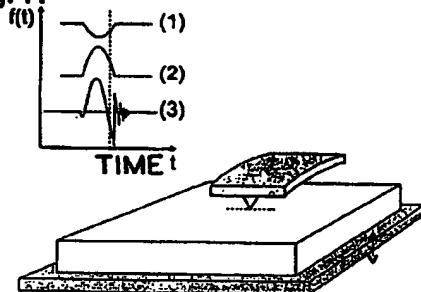


Fig. 7G

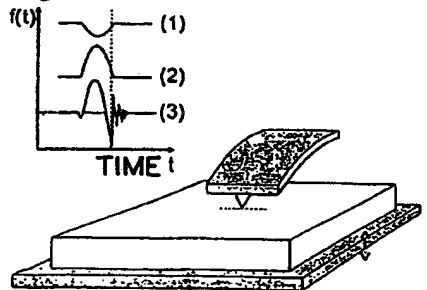
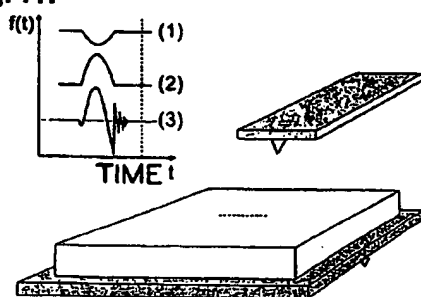


Fig. 7H



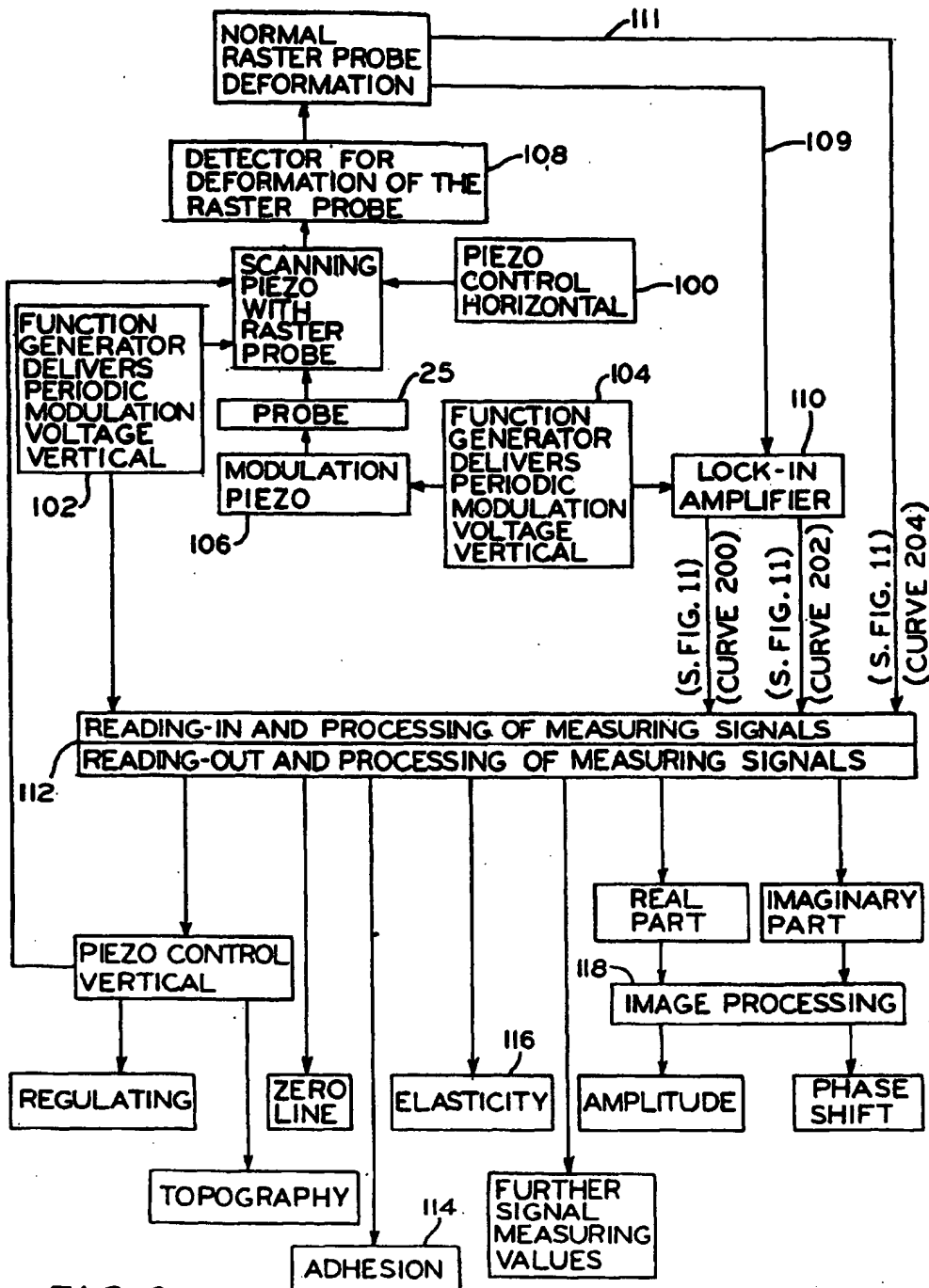


FIG. 8

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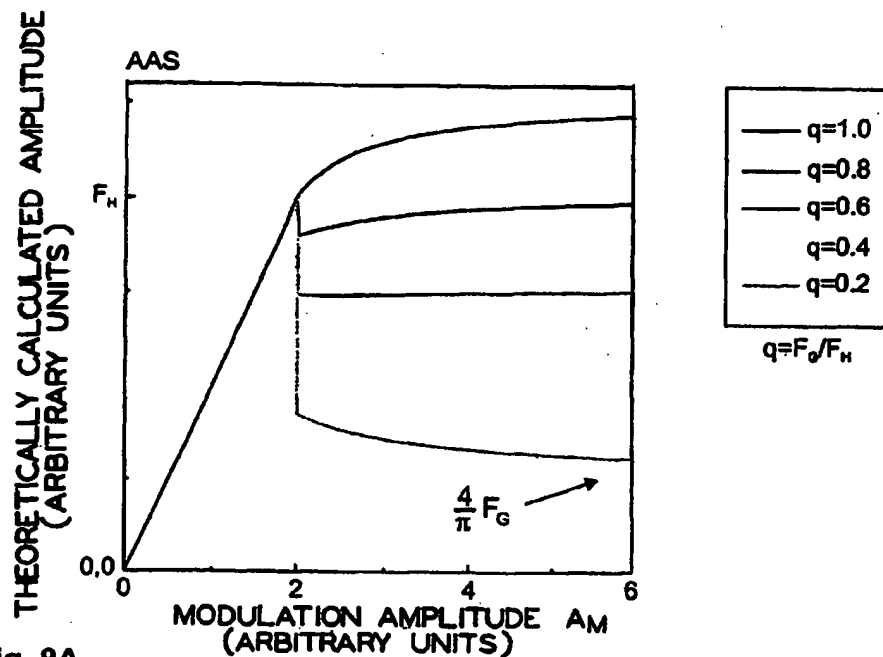


Fig. 9A

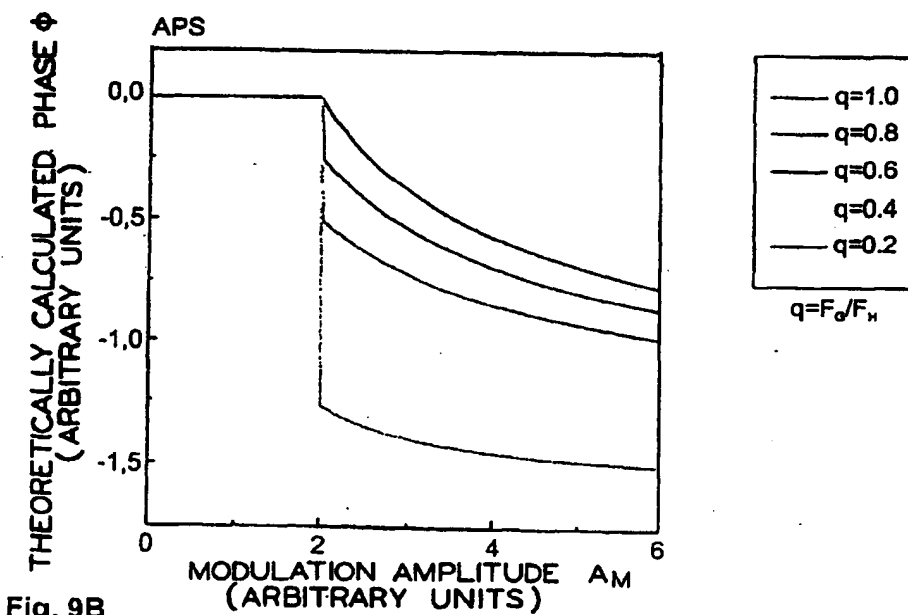


Fig. 9B

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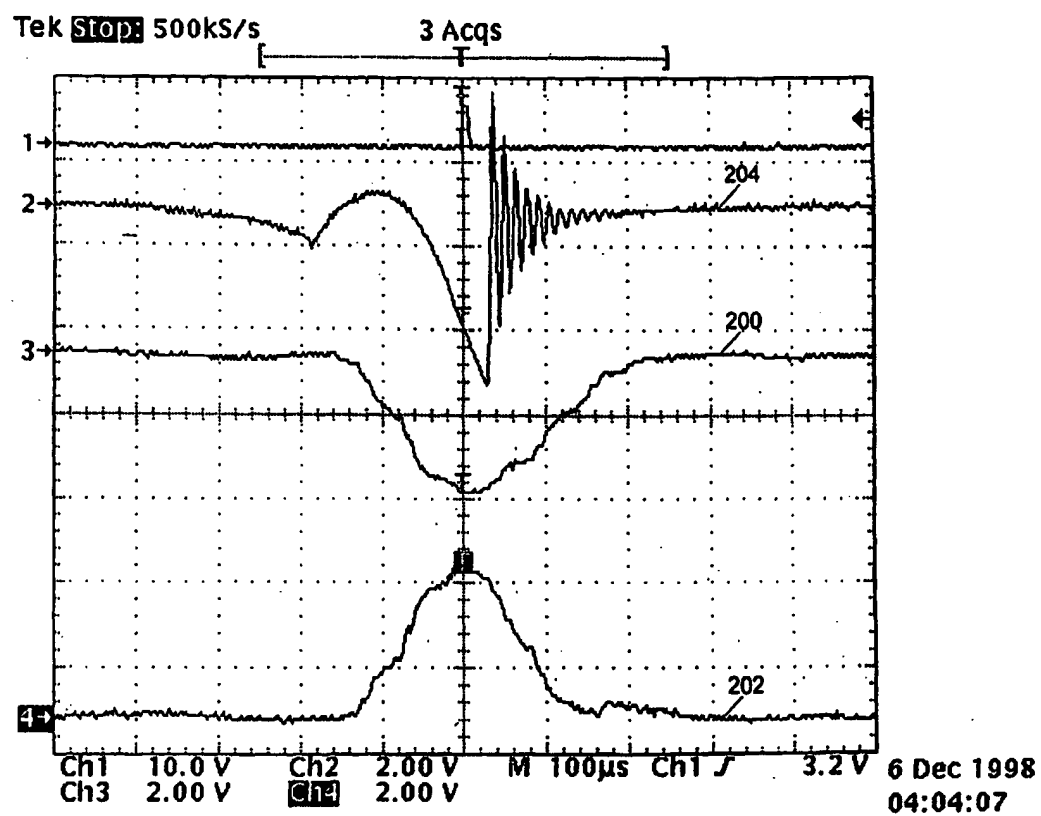


Fig. 10

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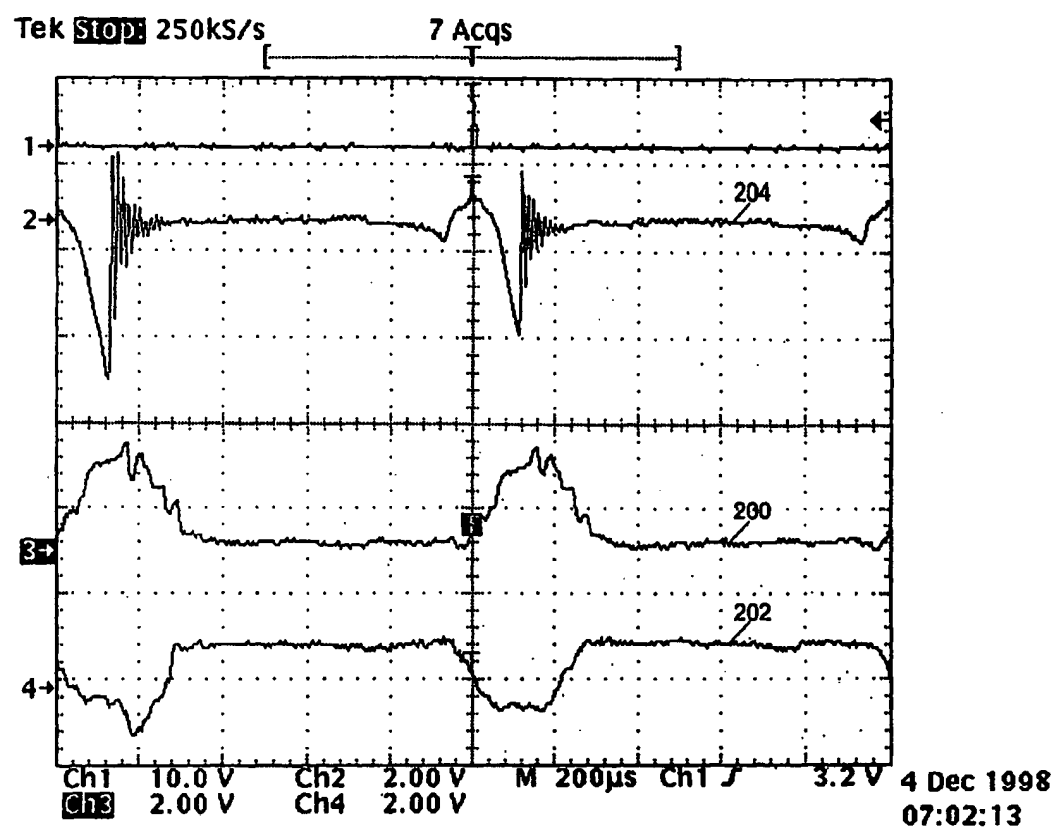


Fig. 11

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POLYMER SAMPLE,  
IMAGE SIZE 25 $\mu$ m<sup>2</sup>,  
93kHz / 1kHz



Fig.12A

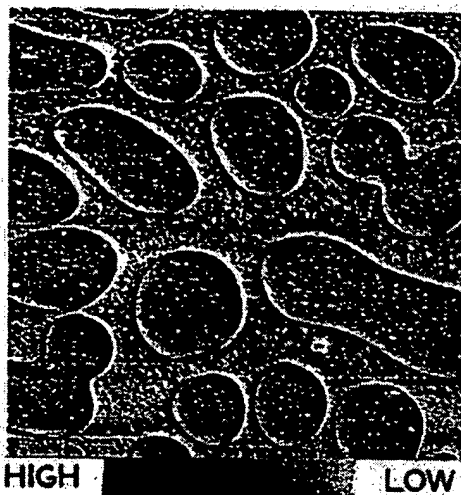


Fig.12B

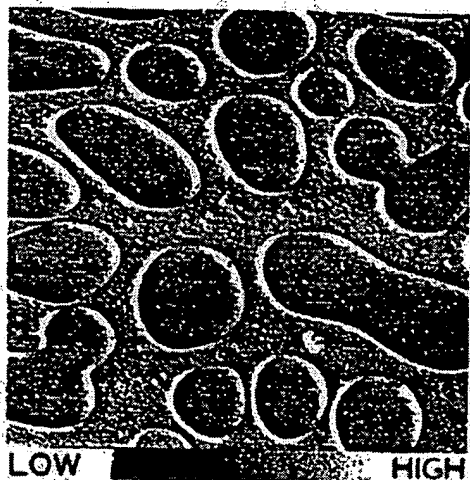


Fig.12C

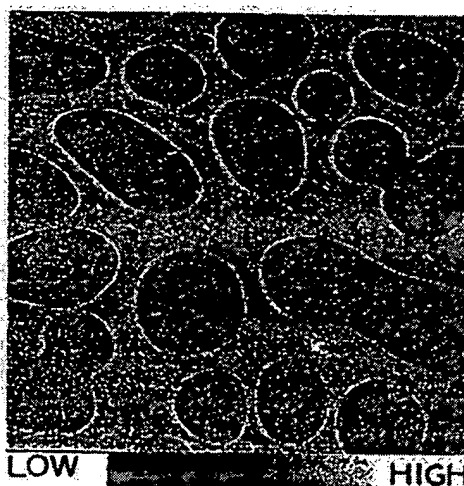


Fig.12D

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POLYMER SAMPLE,  
IMAGE SIZE 25  $\mu\text{m}^2$ ,  
230kHz / 1kHz

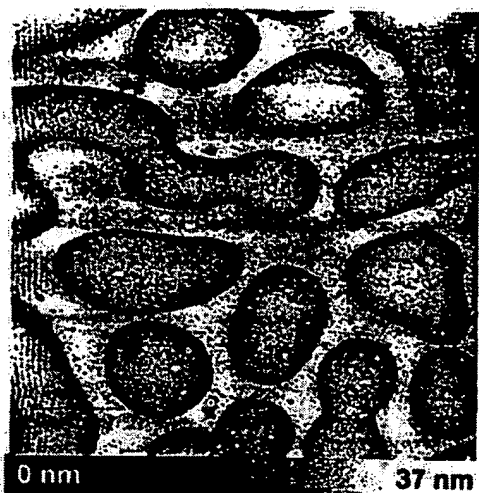


Fig.13A

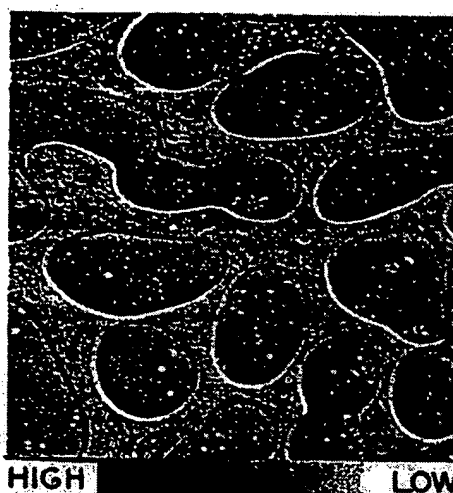


Fig.13B

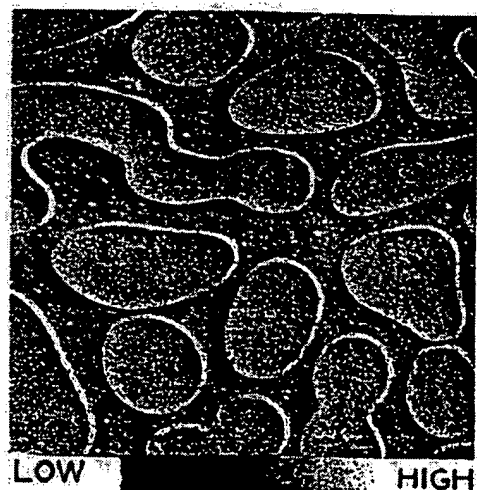


Fig.13C

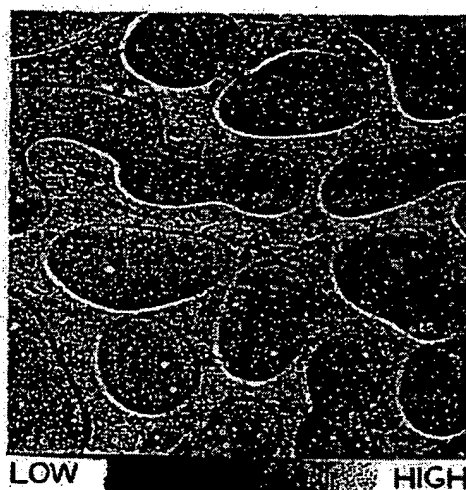


Fig.13D

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